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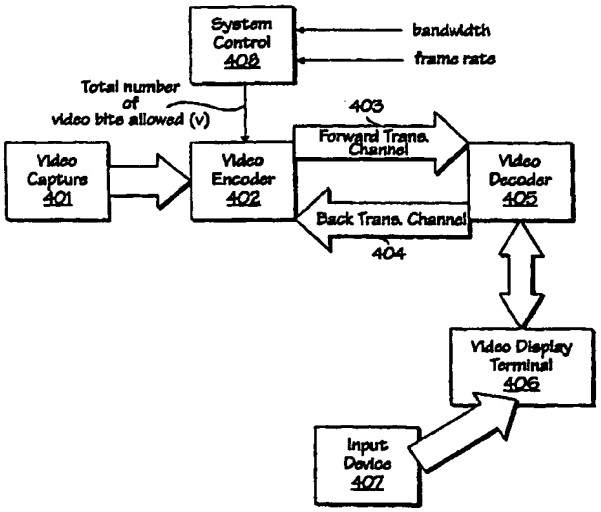
(54) Title: ADAPTIVE VIDEO BIT ALLOCATION BASED ON USER-SELECTED REGION-OF-INTEREST



(57) Abstract

A method and apparatus for displaying a user selected region-of-interest clearly on a video display terminal in an audiovisual conferencing system. The method comprising the steps of having user select his or her region-of-interest on a display terminal (406) with an input device (407), having the video decoder (405) translate the user's selection to corresponding horizontal and vertical coordinates recognizable both by the video decoder and the video encoder (402), having the video decoder transmit the coordinates to the video encoder through a back transmission channel (404), and having the video encoder allocate bits originally for representing compressed video information outside the region-of-interest to represent compressed video information within the interested region of images and transmit the compressed video information to the video decoder (405) through a forward transmission channel (403).

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ADAPTIVE VIDEO BIT ALLOCATION BASED ON USER-SELECTED REGION-OF-INTEREST

FIELD OF THE INVENTION

This invention relates to image signal processing generally and particularly to systems for providing compressed digital video signals representative of a full color video signal.

BACKGROUND OF THE INVENTION

Image data compression is concerned with minimizing the number of bits required to represent an image. Some of the well-known methods are in the areas of pixel coding, predictive coding and transform coding.

Although image compression methods or systems exploit redundancy in the image data and attempt to pack large amount of information into a small number of samples, they often lack the intelligence to determine which object in a particular image needs to be displayed clearly. Such intelligence is important in today's commonly used audiovisual conferencing systems due to these systems' inherent cost and bandwidth constraints. More specifically, many of the audiovisual conferencing systems are based on International Telecommunication Union (ITU) standards such as H.320, published in March, 1993, H.324, published in January , 1996 or H.323, published May, 1996 and thrive on being affordable and operable on a personal computer systems. Consequently, the video compression and decompression schemes in these standards do not require as intensive computation and elaborate buffering mechanism as other more advanced image compression methods. Thus, the resulting images are often not distinctly sharp. Moreover, the line speeds to these said conferencing systems

often range in the 20kps to 384kps. Because of the limited number of data bits available for compressing and transmitting video information, the processed images frequently lack clarity and suffer low frame rates.

Low image quality has hampered the uses of these conferencing systems. For example, a patent attorney may have trouble seeing drawings on a scientist's white board through an audiovisual conference. Similarly, a telecommuter may have trouble viewing the agenda being displayed on the conference room's projector screen. In order to overcome these problems without violating the same aforementioned cost and bandwidth constraints, an apparatus and method is needed to allow an user to select a region-of-interest and display said region with as much clarity as possible under the circumstances.

SUMMARY OF THE INVENTION

An improved method and apparatus for generating a user selected region-of-interest in detail is disclosed. In one embodiment, after a user has selected a region-of-interest, a video decoder in the system translates the selected region to correspond to horizontal and vertical coordinates recognizable both by the system's video decoder and the video encoder. Then the video decoder transmits the coordinates to the video encoder. After the video encoder receives the coordinates, the encoder allocates bits originally for representing compressed video information outside the coordinates to represent compressed video information within the coordinates.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and is not limited by the figures of the accompanying drawings, in which like references indicate similar elements, and in which:

Figure 1 illustrates a video encoder based on ITU H.261 Recommendation.

Figure 2 illustrates some details of the transform coder in Figure 1.

Figure 3 illustrates an example of a quantizer.

Figure 4 illustrates the block diagram of one embodiment of the present invention.

Figure 5 illustrates some details of video encoder in Figure 4.

Figure 6 illustrates a general purpose computer system architecture.

Figure 7 illustrates an add-on board in a general purpose computer system.

Figure 8 illustrates a flow chart describing the process of identifying the region-of-interest in the present invention.

Figure 9 illustrates one example of the geometric relationships between a drawn rectangle and the region-of-interest

Figure 10 illustrates one example of a data packet for transmitting coordinate and dimension information.

Figure 11 illustrates a flow chart describing the bit allocation process.

DETAILED DESCRIPTION

An apparatus and method for allowing a user to select a region-of-interest and displaying said region with as much clarity as possible under the circumstances is described. In the following description, numerous specific details are set forth such as video compression/decompression schemes, quantizers, etc. in order to provide a thorough understanding of the present invention. However, it will be apparent to one of ordinary skill in the art that the invention may be practiced without these particular details. In other instances, well known elements and theories such as transform coding, bit allocation algorithms, quantization, etc. have not been described in special detail in order to avoid unnecessarily obscuring the present invention.

Figure 1 illustrates a block diagram of a prior art video source coder (ITU H.261 Recommendation, published March, 1993). Figure 2 focuses in on the pertinent blocks of Figure 1 for the purpose of discussing the present invention. In particular, block 100 is marked in Figure 1 and further expanded and illustrated in Figure 2. Block 100's functionality is to process video input signal 101 using modules such as cosine transformer 102 and quantizer 103. Transformer 102 performs two-dimensional discrete cosine transforms on input video signal 101. Then quantizer 103 linearly quantizes the output of transformer 102, or its transformed coefficients, with a predetermined step size.

The theory behind transform coding is that a large fraction of the total energy is packed in a relatively few transformed coefficients. Because these coefficients are later quantized independently to provide further data reduction, an optimal transform coder minimizes the overall distortion generated by the quantizer. Figure 3 illustrates a simple quantizer. The quantizer maps a continuous variable u into a discrete variable u'. For example, if $u = u_k$, the corresponding quantized output is u'_k. However, if $u = u_j$, the corresponding

output is still u'_k. As has been demonstrated, a given quantizer output does not uniquely map to one input value. This difference between the input and output values introduces distortion. On the other hand, if quantizer step size 201 becomes smaller, the more accurately input value u will map to output value u' and result in reduced distortion. Unfortunately, introducing more quantizer steps equals requiring more data bits and more computational capabilities to process those bits.

It should be noted that Figure 4 illustrates the block diagram for the invention at hand having been programmed or implemented in various types of systems. One example of the preferred embodiment for the present invention is on a general purpose computer system as illustrated in Figure 6. Such a computer system architecture comprises a bus element for communicating information, a processor coupled with said bus element for processing audio and video information, a random access memory coupled with said bus element for storing static information and instructions for said processor, a data storage device such as a magnetic disk and disk drive coupled with said bus element for storing information and instructions, a readable medium such as a floppy disk or a CD coupled with said bus element for retrieving information and instructions for said processor, an audiovisual device coupled to said bus element for capturing video and audio information, a display device coupled to said bus element for displaying information to the computer user and an alphanumeric input device coupled to said bus element for communicating information and command selections to said processor.

An alternative embodiment for the present invention is an add-on circuit board to a general purpose computer system as illustrated in Figure 7. The circuit board comprises an on-board bus element for communicating information, dedicated Application Specific Integrated Circuits (ASICs) and chip elements coupled with said bus element for encoding and decoding audio and video information, and other ASICs and chip elements coupled to said bus element for

handling the input and the output of audio and video signals. This add-on board is further coupled with the common system bus element in the general purpose computer system.

Yet another alternative embodiment for the present invention is a dedicated audiovisual conferencing system. This type of conferencing system often uses a combination of dedicated hardware components or general purpose processors programmed with particular execution sequences to manage receiving, processing and transmitting audio and video information. Although this embodiment comprises many of the same elements as the general purpose computer system illustrated in Figure 6, it frequently does not offer anything other than the audiovisual conferencing capability.

Despite having disclosed various types of systems above, it will be apparent to one of the ordinary skill in the art that the present invention may appear in other system configurations without exceeding the scope of the present invention.

Operation of the Present Invention

The invention at hand is an apparatus or method for allowing a user to select a region-of-interest, displaying said region with much clarity and at the same time satisfying certain cost and bandwidth constraints. The basic premise of the invention is to allot the system resources, such as the central processing unit's computation cycles and video channel bandwidth, to users' regions-of-interest in a two dimensional image. More specifically, this reallocation scheme consists of two fundamental steps: 1) defining the region-of-interest and 2) allocating available bits from areas outside region-of-interest to region-of-interest.

Using the example of a patent attorney (viewer) and a scientist (displayer) described in the Background section, the flow chart in Figure 8 in conjunction with Figure 4, 9 and 10 describe the first portion of the present invention: the

process of identifying the region-of-interest. More specifically, if the viewer is in an audiovisual conference with the displayer and is interested in seeing the displayer's drawings on the white board more clearly, the viewer can first identify the displayer's white board as the region-of-interest (step 801 in Figure 8). Then with the help of input device 407, the viewer proceeds to draw a rectangle closely around the boundaries of the region-of-interest (step 802). When the rectangle is drawn, a system interrupt is generated (step 803), and some form of a conventional interrupt service routine (ISR) is invoked. During the ISR, certain geometric information of the viewer's chosen rectangle is stored in step 804.

Figure 9 further illustrates step 804. In particular, the previously mentioned white board, or the region-of-interest, 901 is encompassed by the viewer's drawn rectangle 902. In order to determine the exact location of rectangle 902 in reference to an entire image, at least the horizontal and the vertical coordinates for the four vertices must be established. The preferred embodiment, however, collects and records only two sets of values: the first values being the vertical-horizontal coordinates for the upper most left vertex 903 and the second being the values for width 905 and height 904. With values 903, 904 and 905, the coordinates of the four vertices and consequently the area covered by rectangle 902 can be readily calculated.

In step 805, video decoder 405 packages the newly generated values 903, 904 and 905 into data packets 1000 as illustrated in Figure 10. Specifically, coordinate information 1002 contains values from vertex 903, and dimension information 1003 consists of values from width 905 and height 904. Additionally, header 1001 contains a predefined set of control directives such as a packet identifier (for example, differentiating between a data packet and a control packet), a packet type identifier (for example, differentiating between a geometric control packet and a flow control packet) and time stamp information. In constructing the data packet with coordinate information 1002 and dimension information 1003, header 1001 activates both its control packet identifier and the

geometric type identifier. Video decoder 405 then transmits the resulting data packet to video encoder 402 through back transmission channel 404 in step 806.

When video encoder 402 receives data packets 1000, the flow chart in Figure 11 in reference to the block diagrams in Figure 4 and Figure 5 unveils the second portion of the present invention: the method of allocating bits. In the preferred embodiment, system control block 408 establishes a number of bits (or known as V) video encoder 402 can use to compress video images. V is calculated based on the available bandwidth and the desired frame rate. The general mathematical relationship is:

V = bandwidth/frame rate or
= (bits/second)/(frame/second)
= bits/frame

In other words, if a fast connection is available or a low frame rate is acceptable in an audiovisual conference, the compressed video information will possess less distortion. On the other hand, if a high frame rate is required but only a slow connection is available, some video information will be lost or corrupted.

After the value of V is determined, video encoder 402 maintains V and proceeds to extract coordinate information 1002 and dimension information 1003 from incoming data packets in step 1101. By comparing the predefined control directives to the ones in header 1001 of each data packet, video encoder 402 is able to identify the appropriate data packets for further processing. After coordinate information 1002 and dimension information 1003 is distilled from these chosen data packets, horizontal and vertical coordinates are derived from these filtered data. Subsequently, the region-of-interest area is calculated from the derived coordinates.

Having established the region-of-interest, video encoder 402 goes on to select image blocks outside the region in step 1102 and perform two-dimensional

transform coding on them. After the transform coefficients are formulated, video encoder 402 attempts to choose one appropriate quantizer from a bank of available quantizers such as 410 or 411 illustrated in Figure 5. In the preferred embodiment of the present invention, the quantizer with the highest possible quantizer step size in the system is always used for areas outside region-of-interest (step 1103). Consequently, although such a condition introduces much distortion and noise for images in the areas, the number of bits required to encode images in such areas decreases substantially.

The relationship between image quality and the required number of bits for processing video information is further discussed in step 1104. Step 1104 involves dividing the transform coefficients by the selected quantizer step size, or (transform coefficients)/(quantizer step size). The number of bits necessary to represent the resulting quotient is then calculated (known as U). As an illustration, if

transform coefficient = 32
quantizer step size = 2
quotient = 32/2 = 16
The number of bits necessary to represent 16 = 5 bits

However, if

transform coefficient still = 32
quantizer step size = 32
quotient = 32/32 = 1
The number of bits necessary to represent 1 = 1 bit

As has been demonstrated, the higher the quantizer step size is, the less number of bits is required to represent the resulting quotient. On the other hand, because of

the large quantizer step size, small number of allocated bits unavoidably leads to the degradation of image quality.

In step 1105, after having depleted U number of bits to encode areas outside the region-of-interest, the remaining number of bits available for allocation equals to (V - U). Further, step 1106 uses the number (V - U) in deciding on a suitable quantizer Since U has been minimized, the value of (V - U) should produce the maximum number of allowable bits to encode image blocks in a given area. By applying the mathematical relationships established in earlier equations, the resultant quantizer for the region-of-interest will have the most number of steps but with the smallest step sizes. Because small step sizes diminish the discrepancy between the actual video input and the quantized output substantially, the image quality for the interested region will improve noticeably.

In brief, the bits which are normally used to encode image blocks outside the region-of-interest have been reallocated to encode blocks within the region-of-interest. Then the encoded image blocks from different quantizers are transmitted to video decoder 405 through forward transmission channel 403. Referring back to the patent attorney and the scientist example, the likely outcome utilizing the present invention will generate a distinctly sharper image of the white board and a more blurry image of the surroundings of the white board on display terminal 406.

Alternative Embodiment Considerations

Although transform coding is used in describing some embodiments of the present invention, other video compression and decompression schemes can be used without altering the scope of the invention.

Additionally, the discussed method for selecting the region-of-interest involves drawing a rectangle to encompass the region. Other geometric enclosures, such as circles, triangles, or even irregularly shaped enclosures can all be used with similar results. Furthermore, the region-of-interest does not need to be defined by manually operating an input device, such as a mouse. Speech

description or even human eye ball movements are some other alternative indicators to help determine the region-of-interest.

Lastly, even though one described embodiment always uses the quantizer with the highest quantizer step size for areas outside of the region-of-interest, other quantizer selection algorithms can be applied without exceeding the spirit of the present invention.

Thus, an improved video encoding scheme for an audiovisual conferencing system has been described. Although the present invention has been described particularly with reference to the figures, it will be apparent to one of the ordinary skill in the art that the present invention may appear in any of a number of other image compression and decompression systems. It is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the present invention.

CLAIMS

1. A method of generating a user selected region-of-interest in detail, the method comprising the steps of:
   a. a video decoder for translating a selected region-of-interest into corresponding horizontal and vertical coordinates recognizable by both said video decoder and a video encoder; and
   b. said video encoder for allocating bits originally for representing compressed video information outside said coordinates to represent compressed video information within said coordinates.

2. The method according to claim 1, wherein step (b) comprises identifying corresponding transform coefficients and quantizers within said coordinates, taking bits representing video information from regions outside of said coordinates and allocating said bits to said transform coefficients and quantizers.

3. The method according to claim 1, wherein step (a) comprises having said video decoder send said coordinates to said video encoder through a back transmission channel.

4. The method according to claim 1, wherein said region-of-interest is selected with an input device.

5. The method according to claim 1, wherein said region-of-interest is defined by drawing a geometric enclosure around said region-of-interest.

6. An apparatus for generating a user selected region-of-interest in detail, the apparatus comprising:

a. means for translating a selected region-of-interest into corresponding horizontal and vertical coordinates recognizable by both a video decoder and a video encoder; and
b. means for allocating bits originally for representing compressed video information outside said coordinates to represent compressed video information within said coordinates.

7. The apparatus according to claim 6, wherein means for allocating bits further comprises means for identifying corresponding transform coefficients and quantizers within said coordinates, taking bits representing video information from regions outside of said coordinates and allocating said bits to said transform coefficients and quantizers.

8. The apparatus according to claim 6, wherein means for translating a selected region-of-interest into corresponding horizontal and vertical coordinates further comprises means for having said video decoder send said coordinates to said video encoder through a back transmission channel.

9. The apparatus according to claim 6, wherein said region-of-interest is selected with an input device.

10. The apparatus according to claim 6, wherein said region-of-interest is defined by drawing a geometric enclosure around said region-of-interest.

11. An apparatus for generating a user selected region-of-interest in detail, the apparatus comprising:
a. a video decoder for translating a selected region-of-interest into corresponding horizontal and vertical coordinates recognizable by both said video decoder and a video encoder; and

b. said video encoder for allocating bits originally for representing compressed video information outside said coordinates to represent compressed video information within said coordinates.

12. The apparatus according to claim 11, wherein said video encoder further identifies corresponding transform coefficients and quantizers within said coordinates, takes bits representing video information from regions outside of said coordinates and allocates said bits to said transform coefficients and quantizers.

13. The apparatus according to claim 11, wherein said video decoder sends said coordinates to said video encoder through a back transmission channel.

14. The apparatus according to claim 11, wherein said region-of-interest is selected with an input device.

15. The apparatus according to claim 11, wherein said region-of-interest is defined by drawing a geometric enclosure around said region-of-interest.

16. An audiovisual conferencing system comprising:

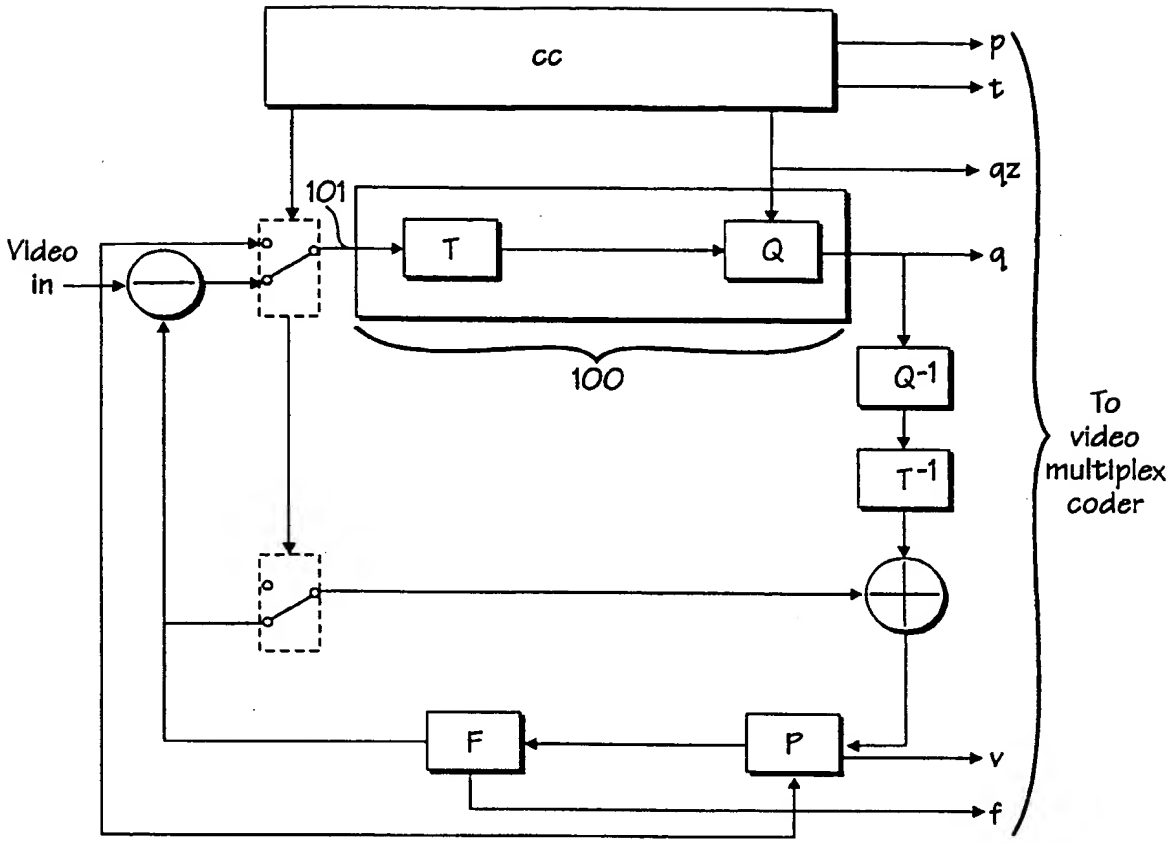
a. a video encoder and a video decoder connected by a forward and a back transmission channel;
b. a video display terminal;
c. an input device allowing a user to select a region-of-interest on said display terminal;
d. said video decoder for translating said selected region-of-interest into corresponding horizontal and vertical coordinates recognizable by both said video decoder and said video encoder;

e. said video encoder for allocating bits originally for representing compressed video information outside said coordinates to represent compressed video information within said coordinates.

17. The audiovisual conferencing system according to claim 16, wherein said video encoder identifies corresponding transform coefficients and quantizers within said coordinates, takes binary bits representing video information from regions outside of said coordinates and allocates said binary bits to said transform coefficients and quantizers.

18. The audiovisual conferencing system according to claim 16, wherein said input device is a mouse.

19. The audiovisual conferencing system according to claim 16, wherein said region-of-interest is defined by drawing a geometric enclosure around said region-of-interest.



T Transform
Q Quantizer
P Picture memory with motion compensated variable delay
F Loop filter
CC Coding control
p Flag for INTRA/INTER
t Flag for transmitted or not
qz Quantizer indication
q Quantizing index for transform coefficients
v Motion vector
f Switching on/off of the loop filter

Fig. 1
(PRIOR ART)

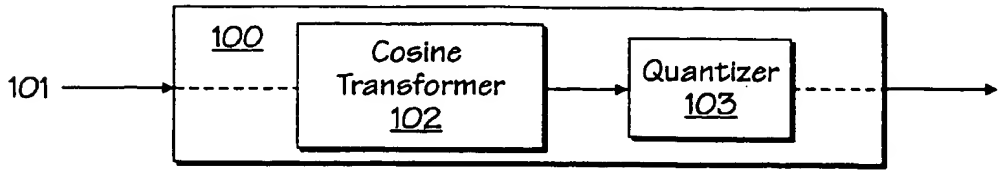


Fig. 2

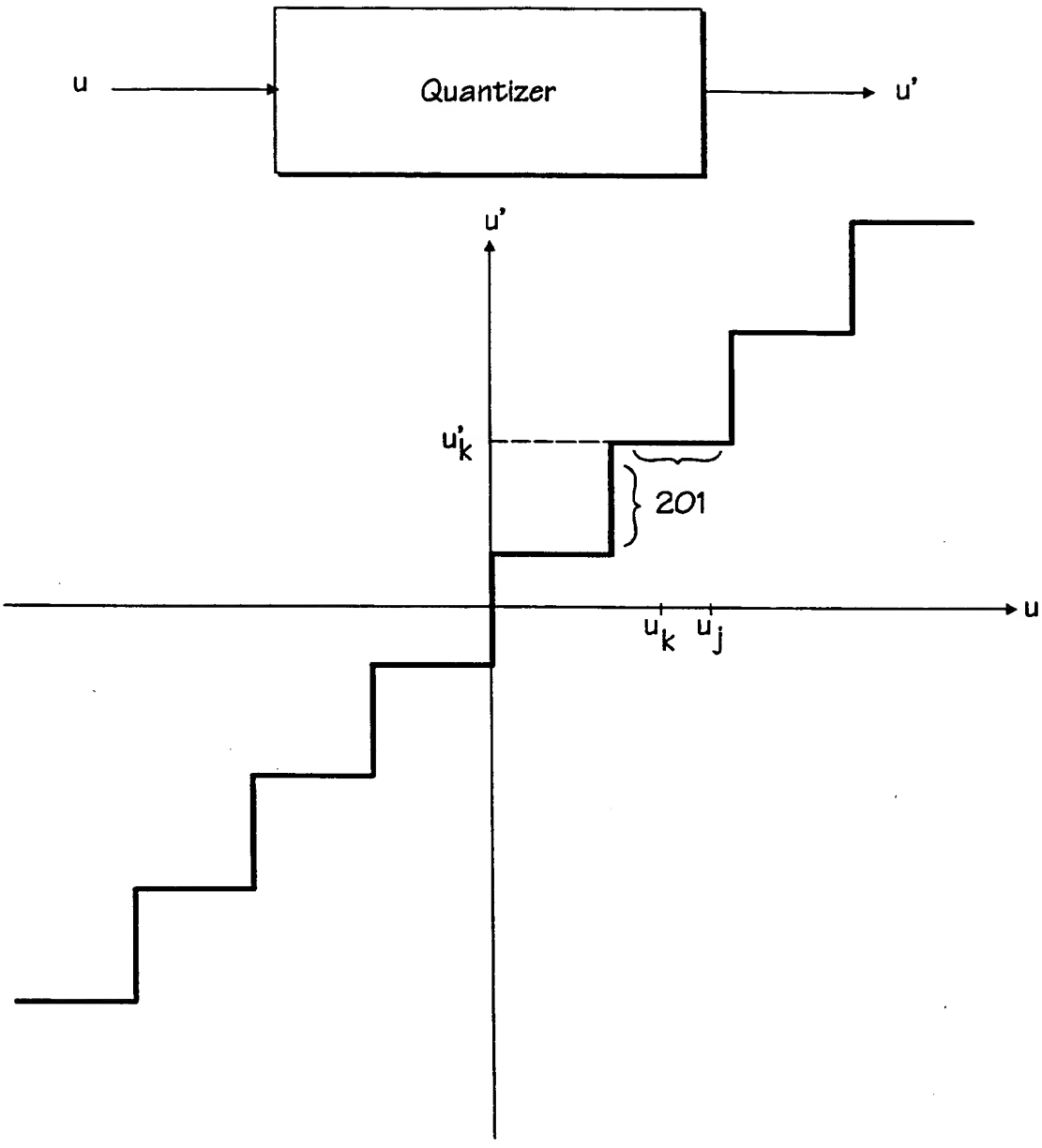


Fig. 3

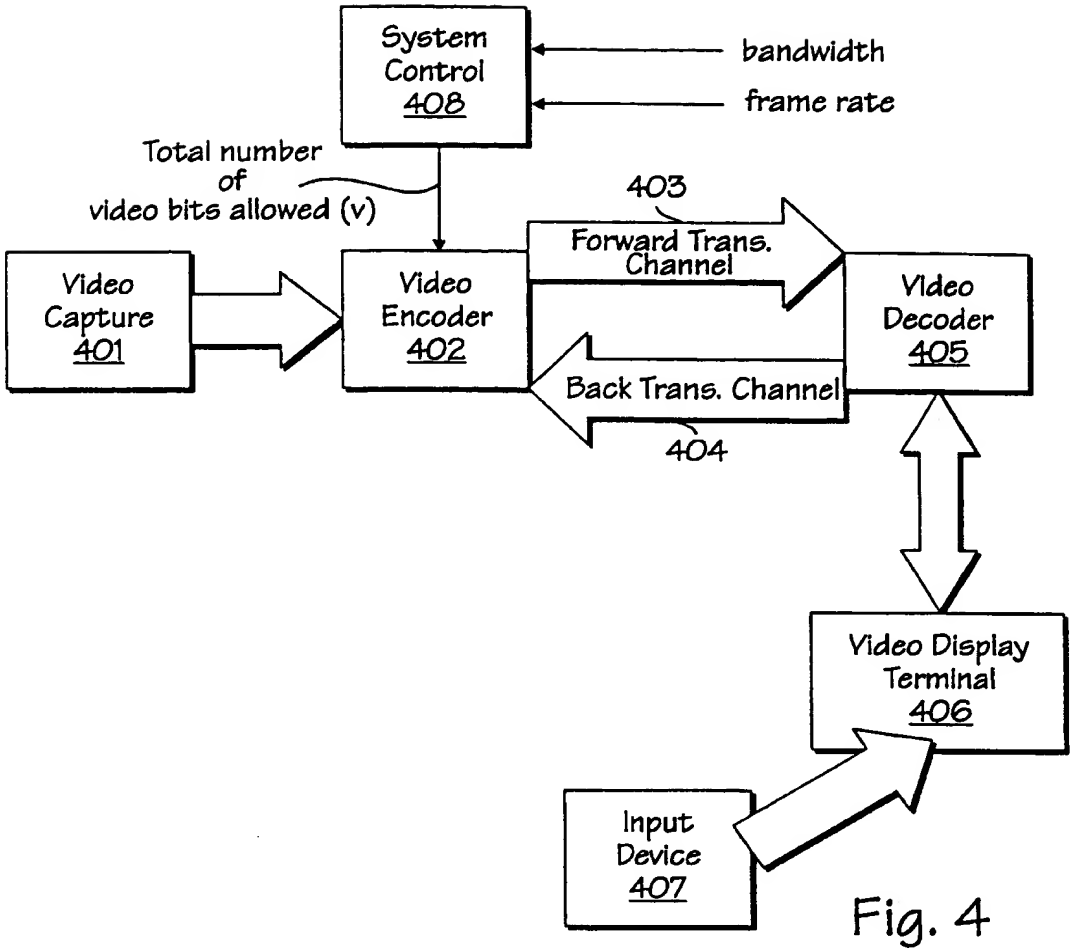

System Control 408
bandwidth
frame rate
Total number of video bits allowed (v)
403
Forward Trans. Channel
Video Capture 401
Video Encoder 402
Video Decoder 405
Back Trans. Channel
404
Video Display Terminal 406
Input Device 407

Fig. 4

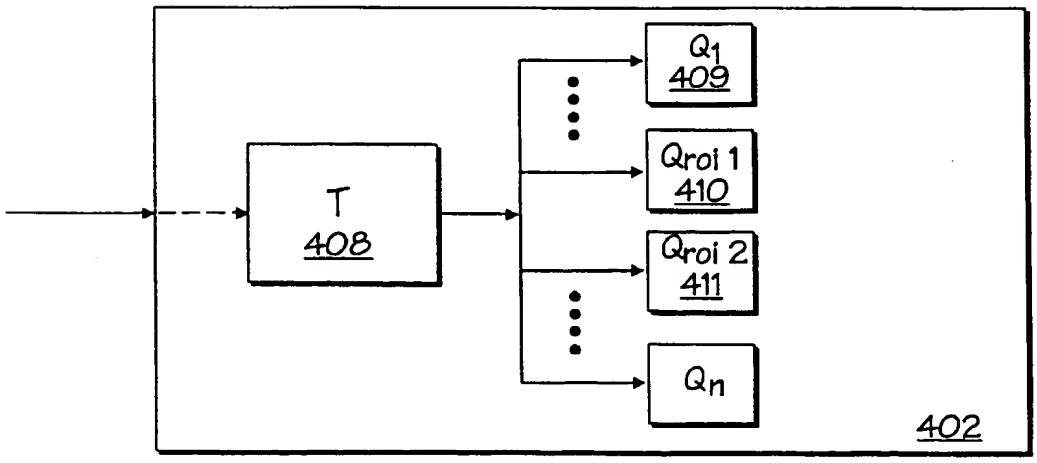

T 408
Q1 409
Qroi 1 410
Qroi 2 411
Qn
402

Fig. 5

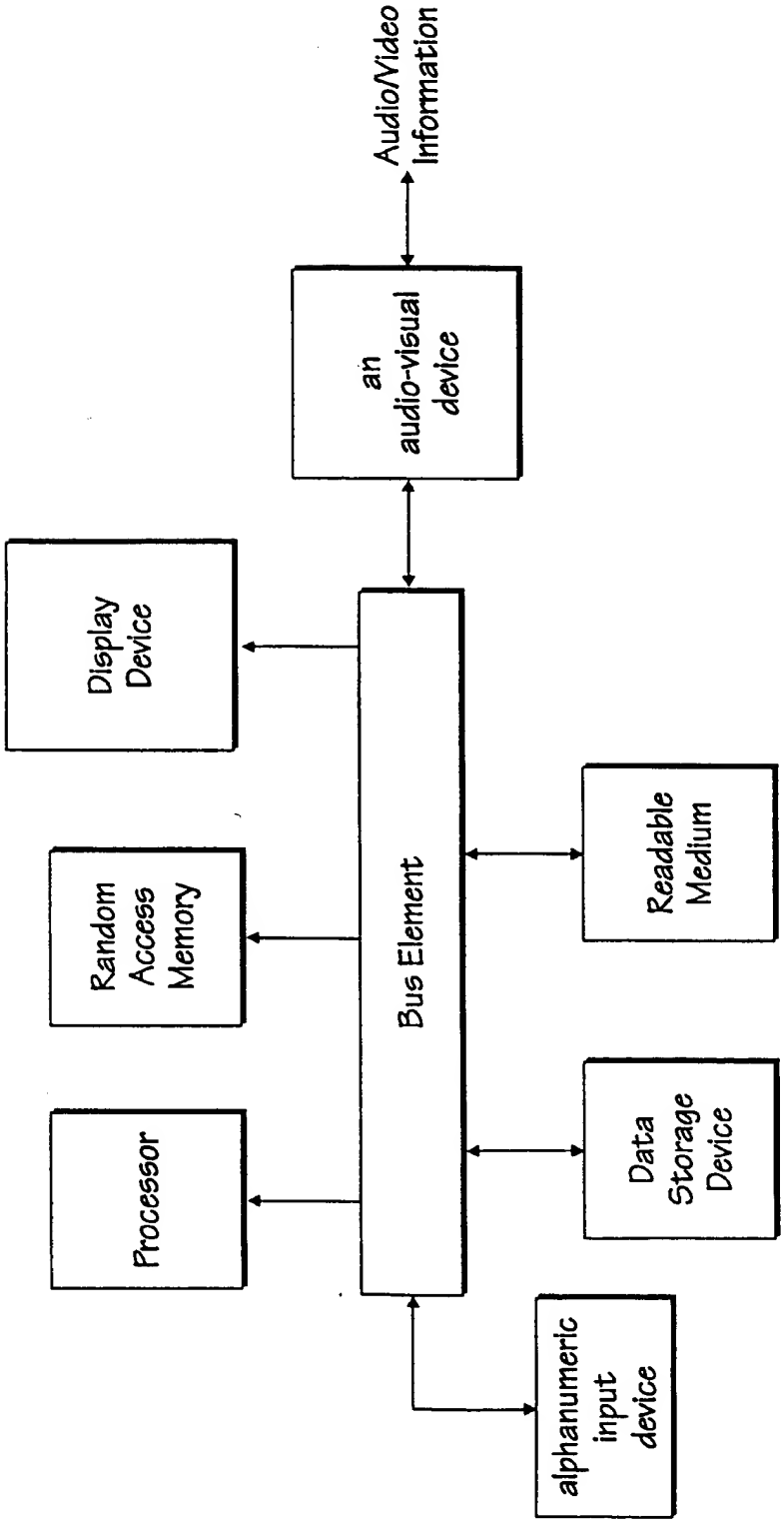

Audio/Video Information
an audio-visual device
Display Device
Bus Element
Random Access Memory
Readable Medium
Processor
Data Storage Device
alphanumeric input device

Fig. 6

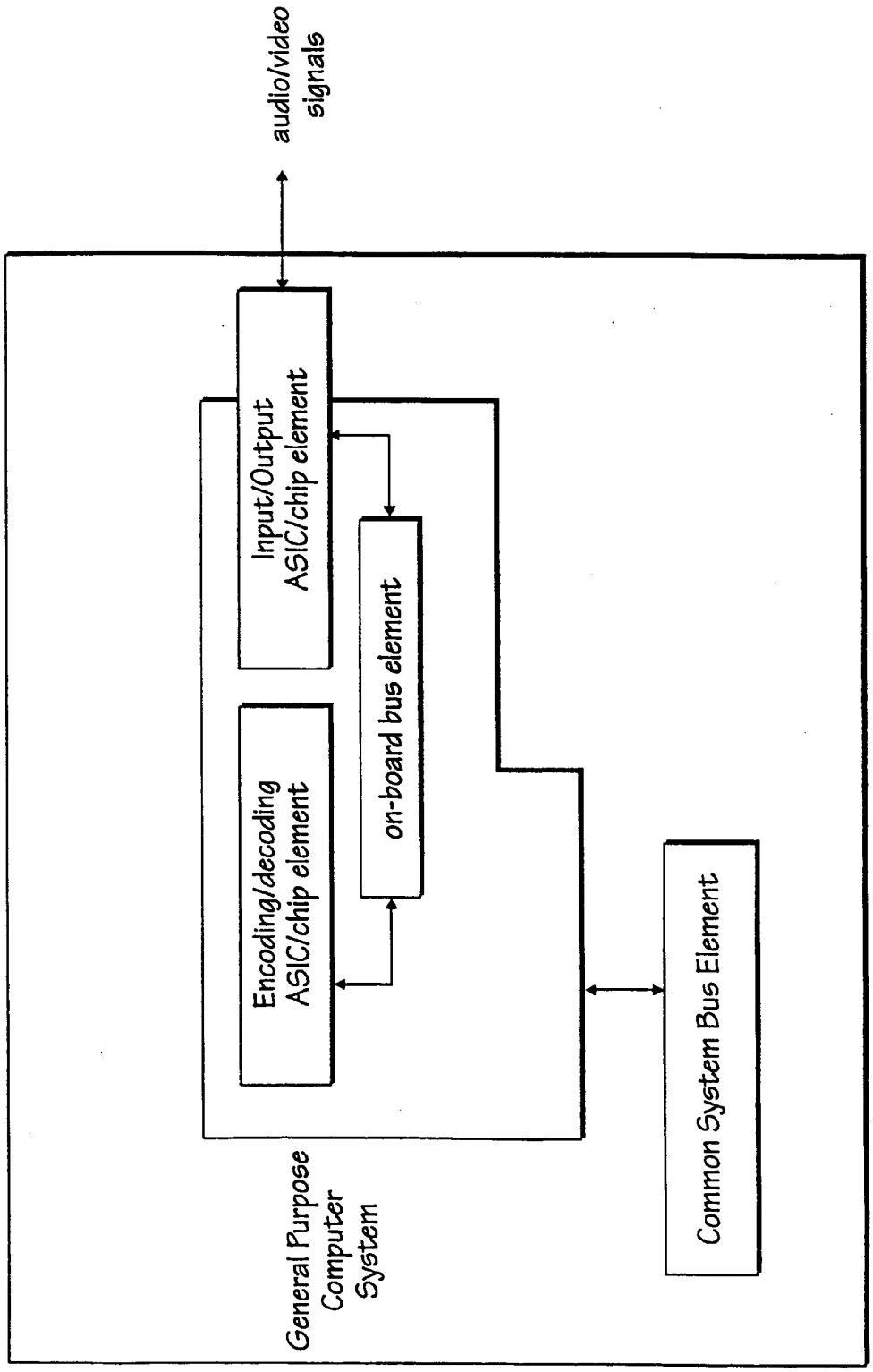

audio/video signals
Input/Output ASIC/chip element
on-board bus element
Encoding/decoding ASIC/chip element
Common System Bus Element
General Purpose Computer System

Fig. 7

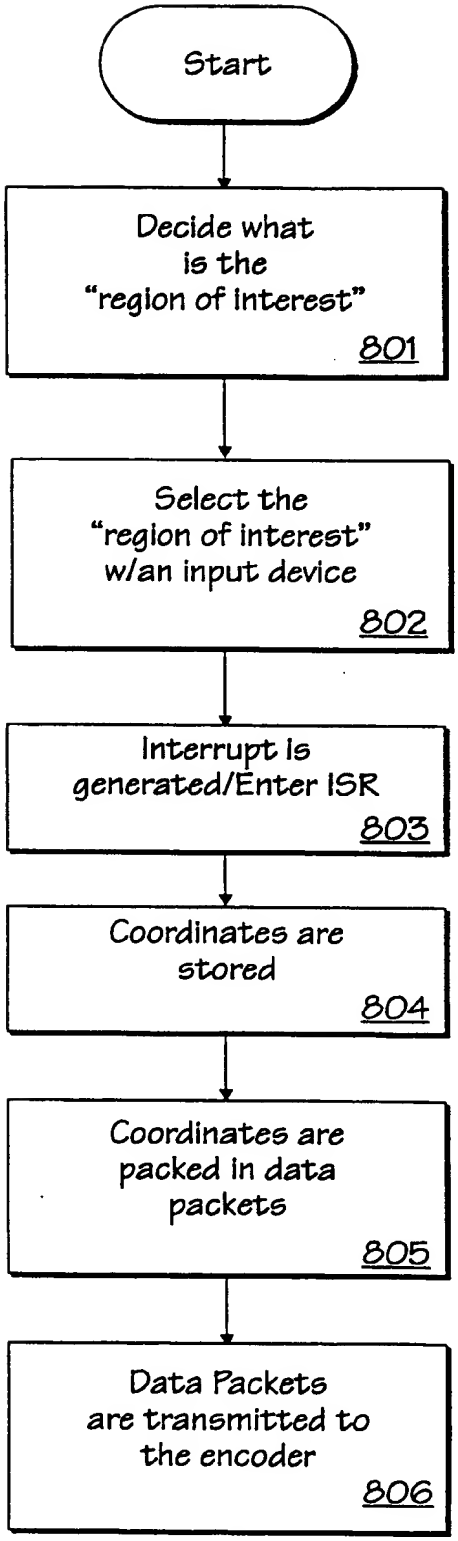

Start
Decide what is the "region of interest"
801
Select the "region of interest" w/an input device
802
Interrupt is generated/Enter ISR
803
Coordinates are stored
804
Coordinates are packed in data packets
805
Data Packets are transmitted to the encoder
806

Fig. 8

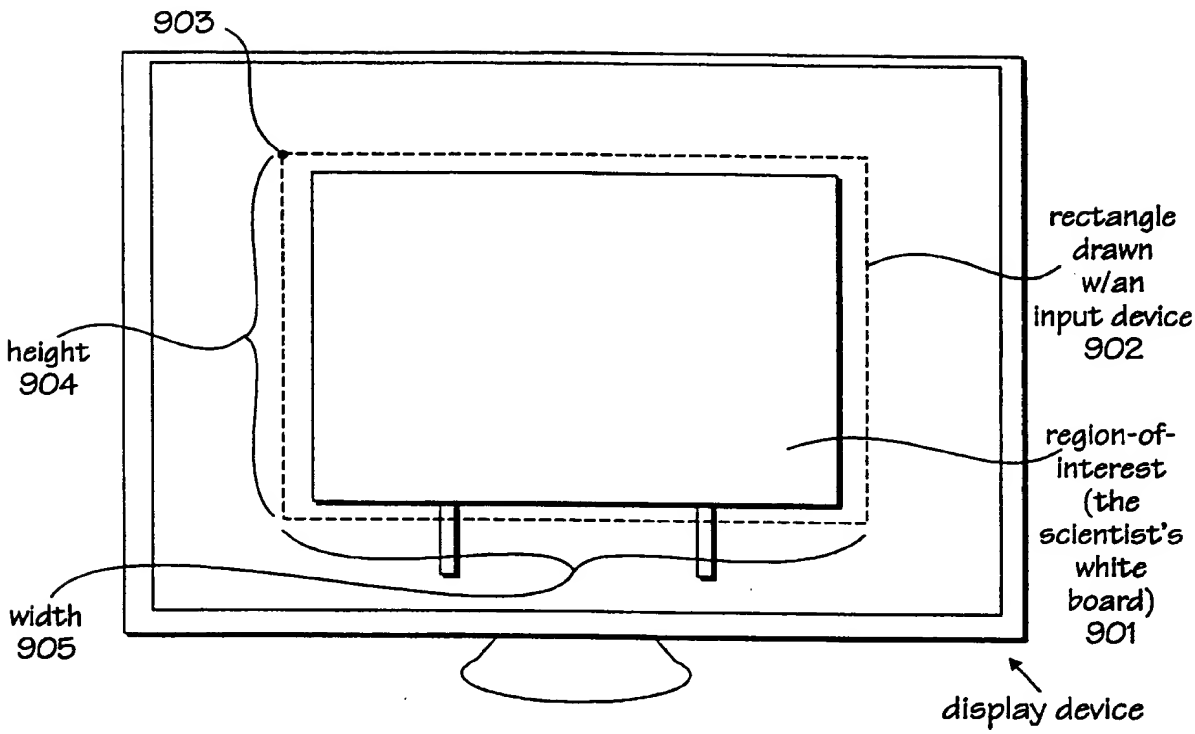

903
rectangle drawn w/an input device 902
height 904
region-of-interest (the scientist's white board) 901
width 905
display device

Fig. 9

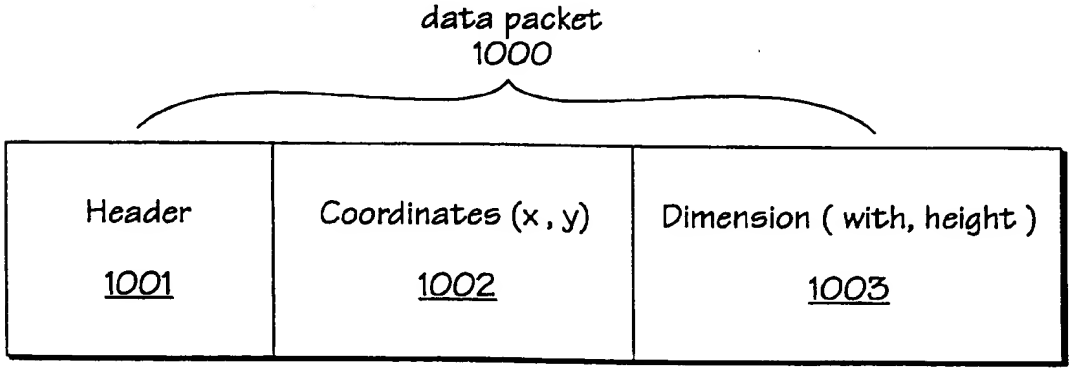

data packet 1000
Header 1001
Coordinates (x , y) 1002
Dimension (with, height) 1003

Fig. 10

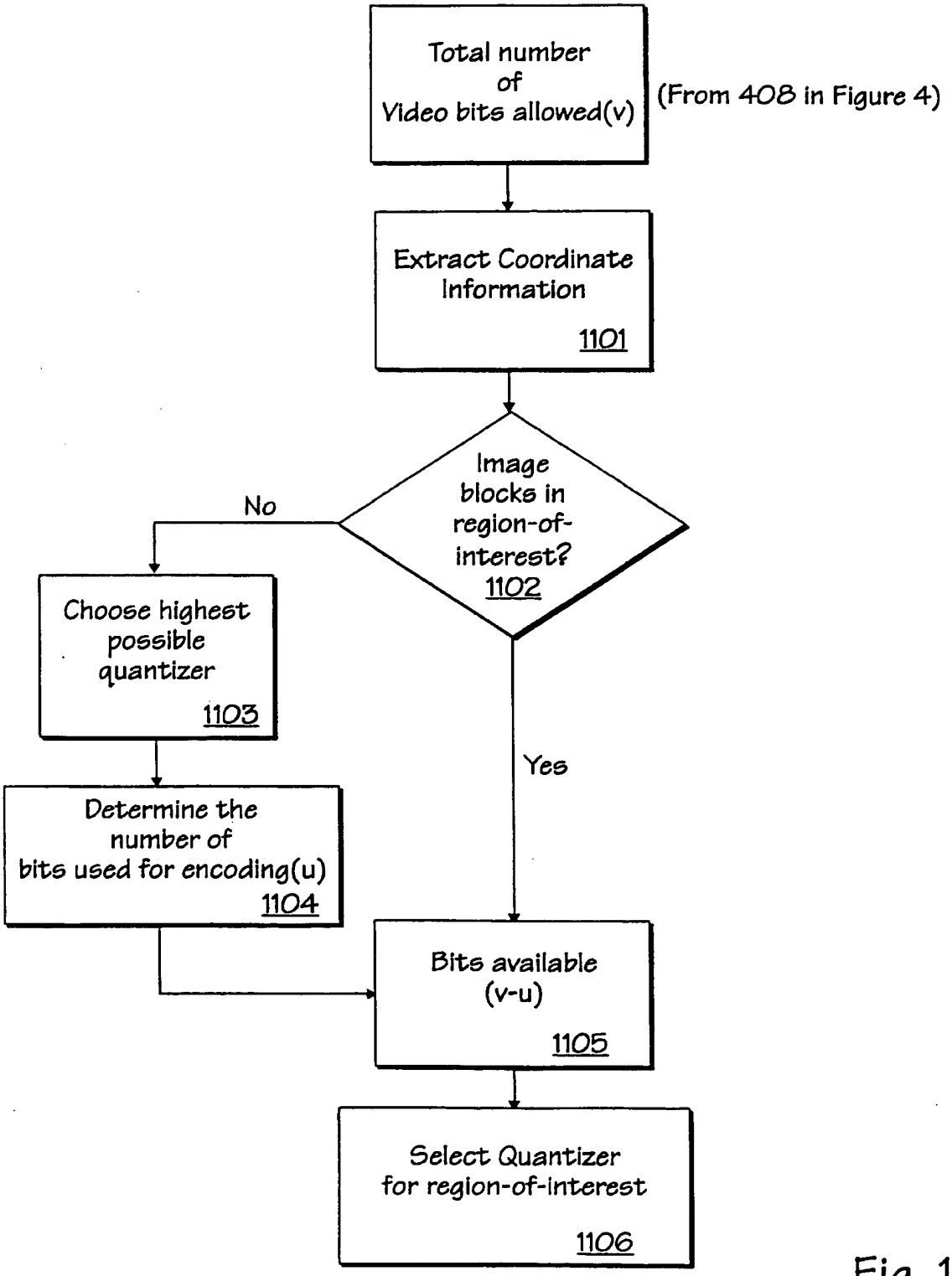

Total number of Video bits allowed(v)
(From 408 in Figure 4)
Extract Coordinate Information
1101
Image blocks in region-of-interest?
1102
No
Yes
Choose highest possible quantizer
1103
Determine the number of bits used for encoding(u)
1104
Bits available (v-u)
1105
Select Quantizer for region-of-interest
1106

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/06443

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H04N 7/32
US CL :348/403
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 348/384, 390, 400-420, 437-438; 382/232, 236, 238-239, 244, 248; 386/111; 375/240

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
APS, WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,621,429 A (YAMAASHI ET AL) 15 APRIL 1997, FIGS. 1 & 9, COL. 2, LINES 10-67, COL. 12, BEGIN LINE 19 TO COL. 14, LINES 1-37.	1-19
X,P	US 5,880,728 A (YAMAASHI ET AL) 09 MARCH 1999, FIGS. 1 & 9, COL. 13, BEGIN LINE 19 TO COL. 14, LINES 1-44.	1-19
X	US 5,598,209 A (CORTJENS ET AL) 28 JANUARY 1997, FIGS. 6A-6B, FIG. 7.	1-19
A	US 5,335,296 A (LARKIN ET AL) 02 AUGUST 1994, COL. 2, LINES 19-54.	1-19
A,P	US 5,793,379 A (LAPIDOUS) 11 AUGUST 1998, FIG. 1, COL. 4, LINES 5-25.	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
24 MAY 1999	14 JUL 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer VU LE James R. Matthews Telephone No. (703) 308-6613

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